

# **CLARREO 2015 Directions Discussion**

## **Next Decadal Survey**

*Bruce Wielicki, discussion lead*

***CLARREO SDT Meeting  
UC Berkeley/LBL Berkeley, CA  
April 28-30, 2015***

# Relevant Leadership Changes

- CLARREO:
  - None
- NASA HQ:
  - Steve Volz (SD mission/engineering lead) has taken a job leading NOAA NESDIS. Steve started at NOAA Nov 1.
  - Steve Neeck is acting until a permanent replacement is selected.
  - Gave Steve Neeck a 1 hour brief on the CLARREO mission and the Tech Demo proposals in December, 2014.
  - Gave Steve Neeck the CLARREO SDT report for background material

# Decadal Survey Status

- Terms of Reference Signed by NASA, NOAA, USGS
  - Up for final approval at NRC meeting May 12, 2015
  - Should be publicly available shortly thereafter
- CESAS NRC committee is primary oversight committee for Decadal Survey
- 6 of CESAS members are on NRC Continuity study team
- Wielicki gave 2 slides at April CESAS meeting on next Decadal Survey: lack of a climate observing system, large economic value of one.
  - 20 minutes of discussion of these topics
  - Suggested that the survey should provide both budget “in guide” and “overguide” plans: i.e. in budget vs needed/economic impact level
  - Suggested that quantitative earth science objectives be used as opposed to vague qualitative statements
  - Use of Class D missions to improve cost effectiveness: moderately higher risk for much lower cost

# Decadal Survey Status

- Potential Decadal Survey Schedule
  - May 12 NRC decision on Terms of Reference
  - Soon thereafter (~ 1 month) selection of chair(s)
  - Selection of Steering Committee in summer
  - Meeting of Steering Committee in late summer early fall
  - Steering Committee will organize Panels and decide on process to be used (in consultation with other NRC standing boards)
  - CESAS (Committee on Earth Science and Applications from Space: a standing NRC committee that oversees the Decadal Survey ) may release an initial request in May/June for white papers on science questions (not missions): continuing and emerging questions, science and application value of satellite earth observations.

# Decadal Survey Status

- Potential Decadal Survey Schedule
  - Decadal Survey may then release a second call for white papers (or not). This is not clear and depends on the process chosen by the committee
    - This second call for white papers might not be released until Fall, 2015?
    - Not clear if it would call for missions, instruments, etc.
    - Aerospace will do the cost studies for the Decadal Survey committee
- Final Report in late 2017? Expect 2 year process.
- NRC has a web site open for nominations to serve on the Decadal Survey committee and panels

**How do we get CLARREO to launch?**

# How do we get CLARREO to launch?

- **Activities since the January 2014 SDT Meeting:**
  - Tech Demo IR & RS missions ISS submitted to HQ in July and Sept 2014
    - ~ \$30 to 50M per instrument, LASP, UW, GSFC
  - Risk Reduction Unit instrument build cost estimates submitted to HQ Oct 2014
    - ~ \$22M per instrument, EDU type builds, LaRC, GSFC
  - Continued progress on LaRC and GSFC CDS systems
  - LASP successful second high altitude balloon flight Aug 2014 (30km alt.)
  - UW demonstration of TRL-6 including vacuum testing
  - LaRC instrument design lab for lower mass/power/cost IR spectrometer (small enough to fit on a Pegasus launch vehicle)
  - A wide range of SDT journal publications
    - Improved spectral fingerprinting (RS, and IR)
    - RS intercalibration sampling and polarization dependence models
    - IR/RS OSSEs
    - Use of High accuracy IR benchmark for Weather Prediction
    - Importance of understanding and observing Far-IR surface emissivity

# From Jan 2014 Meeting: Specific Actions in 2014

- Communicating the need to Science/Congress/NASA HQ:
  - Increase rigor of the Economic Value and publish. [Submitted](#).
    - Add mitigation costs, change from step function to phased emissions changes, include Real Option Value as well as NPV.
  - Increase our outreach to climate science leaders on the existing CLARREO papers: especially BAMS, VOI ([Wielicki, team](#))
  - Educate Congress on key points in publications (2 pager)
    - Talk at LaRC April 2015 to 40 congressional staffers from a wide range of states on CLARREO science and economic value: 30 took the 2 page summary
  - Continue to educate NASA HQ as new results are developed
  - Develop inputs to Decadal Survey
    - Improve CLARREO web site
    - *Summary documents on CLARREO science, requirements, instruments, and mission: 1 page (e.g. Congress, public), 3 page, BAMS (20 page), Full 200 page SDT report*

# Specific Actions/Schedule in 2014

- Communicating the need to the science community:
  - Can we get climate modeling and observation community together to discuss how to develop observing requirements for a climate observing system (e.g. D. Anderson, Collins/Feldman, Soden, etc)
  - Very high level paper on lack of a climate observing system and VOI high economic value of one (e.g. Science, Nature Climate Change, Foreign Policy magazine, etc)
- Continued international collaboration
  - UK: Truths studies continue at a low level
  - India: New interest and active discussions between ISRO and NASA starting in May and June 2015.



# EV Competitions/Decadal Survey

**Solicitation Release Year (Future Dates are Best Estimates)**

Call	AO Released	NOI Due	Submittal
EV Mission (EV-2)	6/17/11	7/22/11	9/29/11
EV Instrument 1	2/12	3/22/12	5/08/12
EV Instrument 2	8/7/2013	9/10/13	11/25/13
<b>DS White Papers</b>	<b>Fall 2015?</b>		<b>Early 2016?</b>
<b>EV Instrument 3</b>	<b>January 2015</b>	<b>4/22/15</b>	<b>6/26/15</b>
<b>EV Mission 2</b>	<b>Summer, 2015?</b>	<b>Summer, 2015?</b>	<b>Fall, 2015?</b>

# **Decadal Survey Activities Overview**

# Decadal Survey Schedule

- NASA/NRC/USGS/NOAA terms of reference signed
- May 12 NRC meeting to approve terms of reference, then released publicly
- Executive committee selected by July 2015
- Panels likely selected by Fall 2015
- Call for white papers likely Fall, 2015
- White papers likely due early 2016

# 2015 Key Tasks

- Key journal papers we still need to publish:
  - CLARREO orbit sampling paper (Doelling et al., in draft revision)
  - IR intercalibration sampling paper (Tobin et al., in preparation)
  - IIP and CDS calibration methods and accuracy level papers (UW, LaRC, LASP, GSFC, joint with NIST partners)
  - Improved rigor in Economic value paper (Cooke et al submitted)
  - Broaden BAMS accuracy requirements to other climate variables (Xu, Rose, Roberts, etc in draft)
  - Broader audience Climate Obs/VOI paper
- Updates to Summary SDT Report for CLARREO web site and for background support of decadal survey white paper.
- Input White paper(s) to Decadal Survey (length unknown)

# Perspectives from 2014

- WCRP Grand Challenge on Climate Sensitivity (March, 2014)
  - Bjorn Stevens, Sandrine Bony, and Robert Pincus support
  - invited talk to Climate Symposium 2014
- AMS Radiation Conference: strong support from (July, 2014)
  - Julia Slingo, UK Met Office Chief Scientist
  - Ramaswamy, NOAA GFDL Director
  - Joe Schmetz, EUMETSAT Chief Scientist (Climate Symposium)
- AOGS: (Aug 2014)
  - Terry Nakajima: interested in VOI: everything in Japan is now economically justified space science. Retiring from Univ Tokyo, going to JAXA
- India invited presentations (through Sanjay Limaye at UW) (
  - Strong interest in joint India/U.S. CLARREO mission
  - Working on possible India instrument additions: aerosol or water vapor RO?
  - India provides launch vehicle and spacecraft, U.S. CLARREO instruments?
  - Start higher level discussions with ISRO and NASA in May/June
  - ISRO budget is rising: strong interest from new prime minister
  - Freilich notified and supports the idea



# Perspectives from 2014

- Climate Symposium 2014 (Oct, 2014)
  - Lots of time with Freilich (several hours)
  - Biggest challenge to get CLARREO going remains budget
  - Second challenge for CLARREO is long time scale of payback
  - Agrees with CLARREO quantitative science goals, OSSEs, science value matrix, likes VOI. Thinks NASA missions need more quantitative objectives (e.g. OSSEs could be used more extensively)
  - U.S. congress still not likely to increase funding in current political environment but other nations might
  - Agrees India a good option for initial collaborative mission, but not sure that they would do a long term series of CLARREO with us
  - Hank Revercomb was able to walk Freilich through his poster
  - About 40 to 50% of senior leaders there seem to get the fact that we lack a climate observing system and that the economic value of one is high.
  - The rest are either comfortable with what we have (worked hard to get what we have in JPSS, Sentinel, and Metop satellite observations) or think we need to do more with what we have or are just worried about a specific part of the observing system (i.e. the stovepipe view).

# Perspectives from 2015

- Langley/GSFC senior management meeting on CLARREO to confirm continued commitment to mission both short and long term. Langley center director has CLARREO as highest priority in Earth science
- Presidents budget request including CLARREO in FY2016 and beyond (yesterdays discussions), PPBE submit April 15
- Invited presentation on CLARREO and VOI at the March, 2015 GEOSS (Global Earth Observing System of Systems) Workshop in Norfolk. Very positive feedback from the group
- Invited to present 2 slides at the NRC CESAS (Committee on Earth Science and Applications from Space) discussion of next Decadal Survey: 20 min of discussion
- Upcoming India NASA/ISRO discussions: telecon and then face to face meetings in May/June 2015.



# Summary

- CLARREO Pathfinder a very positive step
- Prepare for Pathfinder in case Congress increases NASA Earth Science budget
- Continue parallel efforts without Pathfinder in case the budget is not passed.
  - NRC Continuity Study (2015)
  - NRC Decadal Survey (2015-2017)
  - EOA Earth Observation Assessment (2015-2017)
  - UK and India Collaborations (Continuing)
  - SDT Science and Journal Publications
  - VOI research
  - Continued education of science community, congress, NASA HQ



# Backup Slides

# How do we get CLARREO to launch?

- Ways to raise priority:
  - Next Decadal Survey recommendations (All)
  - Congress/administration calling for it (Volz)
  - More of the science community outside the CLARREO team advocating for it (Volz)
  - Climate modelers and observation scientists set observation requirements and priorities for a climate observing system: hypothesis based (Collins, Soden)
  - Show how it can save money in other missions (gaps, calibration systems) (Volz)
  - Educate science community on science value, economic value
- Ways to get closer to CLARREO earlier
  - Venture Class (continue to propose) (All)
  - ISS demonstration instrument (contact Volz further on this)
  - Build engineering model instrument/tech demo to mature mission similar to DesdynI investment (contact Volz further on this)



# What is the “Handle” for CLARREO?

- SI Traceability
- Calibration Observatory
- Standards Observatory
- Climate Change Calibrator
- Climate Change Benchmark
- GSICS Reference Spectrometers
- Spectral Fingerprints
- NIST in Orbit
- Climate Sensitivity and Feedbacks
- Solar and Infrared Calibration Reference



# What is the “Handle” for CLARREO?

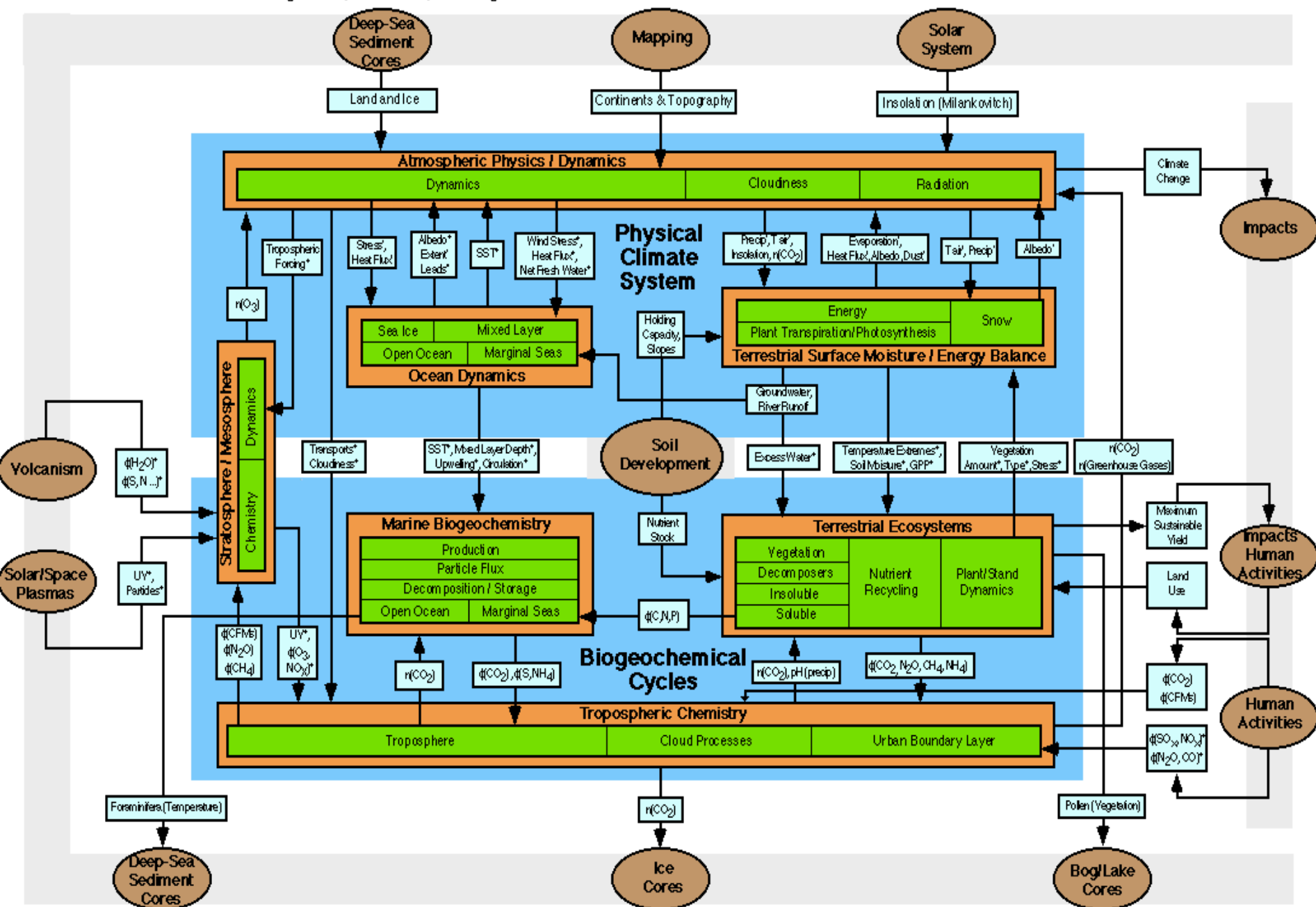
- *Climate sensitivity: the big unknown*
- *No amount of modeling, process studies, field experiments, laboratory experiments, or climatological means can ever determine climate sensitivity with high confidence. These things are all necessary but insufficient. Must also have a multi-decadal climate change accuracy observing system. This last critical element is missing from our climate science efforts.*
- *Multi-decadal climate change accuracy observing system could determine climate sensitivity by itself, but predicting future change will always require climate models.*

# What is the “Handle” for CLARREO?

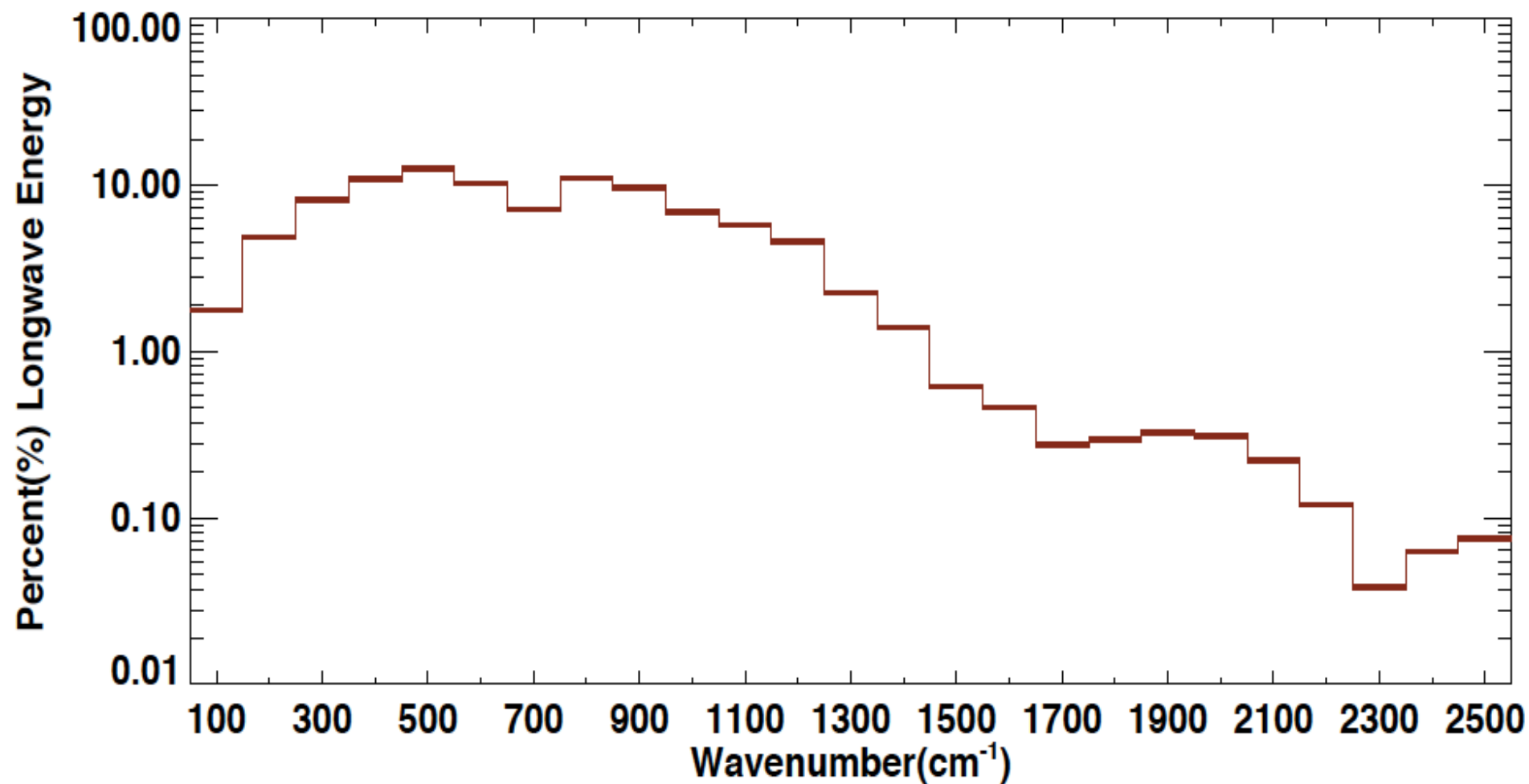
- *Climate change science must observe on 20 – 50yr time scales to exceed natural variability (NOAA climate “normal” = 30yrs)*
- *CLARREO is the only mission with climate change Level 1 requirements that I am aware of (others process/climatology)*
- *EOS was built on the Bretherton diagram: measure a climatology (15 years) and process for all major climate system variables: but NO vision for long term climate change*
- *CLARREO is the first vision for how to go beyond climate process and climatology to include climate change.*
- *Climate change science is deferred gratification on a large scale.*



# CONCEPTUAL MODEL of Earth System process operating on timescales of decades to centuries



Percentage of Total Longwave Thermal Energy  
GLOBAL ANNUAL MEAN C3M/PCRTM/MOA  
per 100cm<sup>-1</sup> Band



Percentage of Total Longwave Thermal Energy  
per 100 cm<sup>-1</sup> band and band mean Brightness Temperature

